CHAPTER I

INTRODUCTION

Skin temperature (ST) retrievals are currently made every hour from 1145 to 2345 UTC at the Global Hydrology and Climate Center (GHCC) in support of near real-time modeling applications. Skin temperature is the radiating temperature of the soil, vegetation, top of the canopy for vegetated surfaces, buildings, roads, water, etc. Often surface temperature refers to the air temperature a couple of meters above the ground, but for this research the actual skin temperatures of the land (land surface temperature (LST)) and sea (sea surface temperature (SST)) are being estimated from satellite data. All future references in this document to LST concern skin temperature measurements or estimates, not surface air temperatures. The GHCC retrieval technique uses the National Oceanic and Atmospheric Administration (NOAA) Geostationary Operational Environmental Satellite (GOES) sensors to derive skin temperature values over much of the United States. The GOES-8 satellite is one of two operational satellites and provides imagery of the eastern CONtinental United States (CONUS) up to four times an hour. The frequency of the retrievals allows the data to be assimilated into numerical models to improve the accuracy of their forecasts (Lapenta et al. 1999). The high temporal resolution of the GOES data also provides the opportunity to study the diurnal variation of radiance derived parameters such as skin temperature. In addition, the probability of

retrieving surface values from areas frequently covered by clouds using GOES is significantly improved over that of polar orbiting satellites because of the almost constant viewing capabilities of GOES.

Ground measurements of land ST are spatially limited and therefore do not provide global coverage. Air temperatures measured a few meters above the ground are available for many locations within the United States, but actual ST measurements are very limited. Skin temperatures derived from geostationary satellite observations have both high temporal and spatial resolutions for much of the globe. Skin temperature measurements are an important input for operational meteorology applications such as model assimilation, nowcasting, and diagnostic studies. Morning skin temperature tendencies (dT/dt) derived from the GOES-8 Imager at the GHCC are currently used for assimilation into a forecast model (Suggs et al. 1999). Land skin temperature measurements have important applications in agriculture including frost detection and warning (Caselles and Sobrino 1989), and determination of water requirements for crops (Jackson et al. 1977). Data products derived from GOES satellites can also be used for diurnal, monthly, and long-term climate studies of surface parameters. Research applications of satellite derived STs include the study of the urban heat island effect (Hafner and Kidder 1999; Lo et al. 1997) and the study of the earth's energy balance (Crag et al. 1995).

The research presented here evaluates ST retrievals from both the GOES-8 Imager and Sounder sensors derived using a Physical Split Window (PSW) technique. The PSW technique uses longwave infrared (IR) window channels to simultaneously retrieve ST and total precipitable water (PW). The PSW retrieval method requires

observations from at least two channels within the 10-13 μm longwave IR atmospheric window. Beginning with the GOES-12 satellite, the 12 μm channel on the Imager will no longer be available, leaving only one Imager longwave IR channel. The Imager will therefore become obsolete with respect to the PSW retrieval technique. The Sounder instrument will continue to have three longwave IR channels available and will therefore provide the observations necessary for the PSW algorithm. This work was initiated because of the upcoming Imager channel change, and the main purpose is to determine if there are any significant differences between the GOES-8 Imager and Sounder ST products.

The retrievals produced by the GOES-8 Imager and Sounder exhibit differences because of variations in spatial resolution, sensor calibration, and spectral band intervals. This research compares retrievals from the two instruments and evaluates the effects of the spatial resolution and sensor calibration differences on the retrievals, in preparation for the loss of the Imager 12 μm channel. Both Imager and Sounder retrievals are also compared to ground truth data (land and sea) to evaluate the overall accuracy of the technique. Analyses of GOES-8 and GOES-11 inter-comparisons of noise and striping and ST retrievals are also presented. Finally, a qualitative comparison between a GOES-8 Imager ST scene and a LST scene derived from data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Earth Observing System (EOS) satellites is made.

Retrievals made at the GHCC from the GOES-8 Imager and Sounder have previously been compared to ground truth (Suggs et al. 2000) and inter-compared (Suggs et al. 2001), and this thesis work continues this research. However, there has been little

additional research on comparisons between the GOES Imager and Sounder products, and the impact of the loss of the Imager 12 μm channel. Skin temperature retrievals are currently produced by NOAA/National Environmental Satellite Data and Information Service (NESDIS) operationally and experimentally by the Imager and Sounder respectively. The derived product imagery (DPI) produced by NESDIS has been evaluated. Hayden et al. (1996) concluded that because of its higher temporal and spatial resolutions, the Imager ST DPI is preferable to the Sounder ST product. Menzel et al. (1998) stated that the accuracy of the Sounder DPIs is greater than that of the Imager DPIs because of the higher number of Sounder spectral bands utilized in the retrieval process. However, this conclusion was only made concerning stability and water vapor products, not the skin temperature product. The overall accuracy of Imager and Sounder DPIs has been evaluated (Rao and Fuelberg 1998; and Menzel et al. 1998) and generally good results were found. However, these evaluations did not include surface temperature analysis, and thus the accuracy of GOES Imager and Sounder ST products is not known.